UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 438

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. PROFESSIONAL PAPER December 11, 1916

THE PEAR LEAF-WORM.

By R. L. NOUGARET, *Entomological Assistant*, and W. M. DAVIDSON and E. J. NEWCOMER, *Scientific Assistants, Deciduous Fruit Insect Investigations.*

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INTRODUCTION.

The pear leaf-worm, more scientifically termed the pear sawfly (*Gymnonychus californicus* Marlatt), is an hymenopterous insect belonging to the family Nematidæ and to the subfamily Nematinæ. For several years it has been noted as a pest on pear trees on the Pacific coast. The observations and experiments recorded herein were made in California by Messrs. R. L. Nougaret and W. M. Davidson, during the years 1911 to 1914, inclusive, and in the State of Washington by Mr. E. J. Newcomer, during the seasons 1914 and 1915.

The injury is caused almost entirely by the feeding of the green wormlike larva and is confined to the foliage, resulting in partial defoliation.

In the localities in which it occurs the insect is quite abundant. Occasionally it becomes a pest of serious consequence, and under favorable conditions it might cause widespread damage.

HISTORY AND DISTRIBUTION.

The pear leaf-worm was described from 1 female collected at Brockport, N. Y., and 10 females taken near Sacramento, Cal., by

NOTE.—This bulletin is of interest to pear growers generally, but especially to those of the Pacific coast.

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Matthew Cooke (1)[1] in the year 1881. At that time it was reported also from Natoma and Santa Clara, Cal. In the spring of 1909 it was quite common in the vicinity of Stanford University, Cal., and in 1911 it was a pest in Tehama County, Cal., besides being generally distributed throughout the central counties, both on the coast and in the great interior valleys of Sacramento and San Joaquin? (3) As to neighboring States, Prof. H. F. Wilson, of the University of Wisconsin, in a letter reports the insect attacking pear foliage in Oregon (1913); Dr. A. W. Morrill, State entomologist of Arizona, states in a letter that Arizona is free from the insect (1913); Prof. C. P. Gillette states that the insect does not appear to live in Colorado. In Washington it was found in pear orchards in the Wenatchee Valley in 1914 and 1915, being particularly abundant in an orchard about 6 miles from Wenatchee, but careful inquiry did not lead to the discovery of other orchards having more than a scattering infestation.

Mr. C. L. Marlatt, in describing this insect, states that Dr. J. A. Lintner, former State entomologist of New York, reported an undetermined sawfly larva as being injurious to pear in a nursery at Geneva, N. Y., in May, 1894. Mr. Marlatt says (2)[1] it is probable that this is the same species, but as it has not been reported since, so far as known, the identification of the Geneva specimens remains doubtful; however, the collection of a specimen at Brockport, N. Y., indicates that it may be found in the East.

POSSIBLE ORIGIN.

An attempt was made in Washington to ascertain the natural hosts of the pear leaf-worm. The fact that it is found in various localities throughout a range of a thousand miles would indicate that it is a native species. Two wild plants related to the pear are to be found in the vicinity of Wenatchee, Wash. These are the service berry (*Amelanchier cusickii* Fern.) and the thorn apple (*Crataegus brevispina* Dougl.). Plants of both species were searched carefully for larvæ of the sawfly several times in May. Nothing was found on the service berry, but the thorn apple yielded a number of green larvæ very similar to those on pear. They differed, however, in being a more shiny green, and in having scattered brown dots laterally and dorsally on the thorax. A number of these were reared, but the adults have not yet emerged. It is very probable that they belong to a distinct but closely related species.

Nearly full-grown larvæ of the pear leaf-worm were placed upon twigs of both the service berry and the thorn apple. Those on the former fed a little, but soon dropped off and died, while the larvæ on the latter at once began to feed, and several of them matured and spun cocoons. From this it may be inferred that the pear leaf-

[1] Figures in parenthesis refer to "Bibliography," p. 23.

worm may naturally feed upon the thorn apple, and if a native of the Pacific coast there probably exists another host to which it is adapted, and its habit of feeding upon pear may be an acquired one. This is not impossible, as various species of Crataegus and of Sorbus occur throughout the known range of the species.

CHARACTER AND EXTENT OF INJURY.

The injury caused by the pear leaf-worm (fig. 1) is confined among economic plants to the foliage of the pear and is due chiefly to the larva. While it consists primarily in the eating out of circular or semicircular holes in the leaf (fig. 1, *a*, *b*), often whole leaves are eaten down to the petiole. During its period of life a single larva eats about one-fourth of an average-sized pear leaf, so that it requires several larvæ to consume such a leaf entirely. When two or more larvæ are feeding simultaneously on the same leaf they frequently cut the midrib in two at about the middle of the leaf, and the portion thus cut off falls to the ground. Severe infestations cause the defoliation of branches (Pl. II, fig. 2). The larvæ are not addicted to roaming and commonly do not leave their original leaf as long as any edible part of it remains. In Washington many trees were observed in 1914 that were from one-third to nearly one-half defoliated. Such infestations, however, are not common. The lower parts of large trees are the more heavily infested.

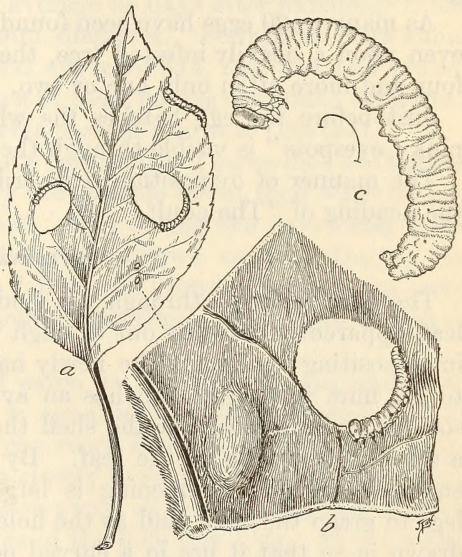


FIG. 1.—The pear leaf-worm (*Gymnonychus californicus*): *a*, Leaf showing character of injury and egg in situ; *b*, enlarged section of leaf showing egg in tissue and manner of feeding of young larva; *c*, full grown larva. *a*, Slightly enlarged; *b*, *c*, much enlarged. (Original.)

The eggs are usually laid in leaves that are not yet unrolled, and those which fail to hatch often deform or curtail the growth of the leaf, possibly by cutting off its food supply between the point where the egg was deposited and the edge of the leaf, making the latter one-sided (Pl. I, fig. 3). When the eggs hatch normally this malformation does not occur. The puncture of the ovipositor frequently causes a discoloration of the adjacent tissues and sometimes wilts young, tender leaves.

The larva apparently will eat the foliage of all cultivated varieties of pear.

DESCRIPTION AND HABITS.

THE EGG.

The egg (fig. 1, *a*, *b*) appears on the surface of the leaf as a small oval blister of a greenish color. It is reniform, slightly smaller at one end, translucent greenish, and about 0.75 mm. in length and 0.50 mm. in maximum width. As the margins of the egg are more or less covered by the edges of the ruptured epidermis of the leaf to which it adheres, it is hard to remove the egg intact. This incised part of the leaf epidermis appears as a narrow brownish area surrounding the egg. On the lower surface of the leaf nothing is visible but a dark spot, indicating the passage of the ovipositor. The egg is slightly more oval than that of the pear slug (*Caliroa cerasi* L.), which it greatly resembles.

As many as 20 eggs have been found in a single leaf, but ordinarily, even upon a heavily infested tree, there are not more than three or four and more often only one or two.

Just before the egg hatches the whitish curved embryo with its pink "eyespots" is visible through the shell.

The manner of oviposition is described later in this section under the heading of "The adult."

THE LARVA.

The larva emerges through the epidermis of the underside of the leaf, apparently crawling out through the incision made by the adult in depositing the egg. The newly hatched larva measures 1.3 mm. to 1.7 mm. in length, and has an average width of 0.35 mm. As soon as its head is free of the shell the larva begins to feed, cutting a small round hole in the leaf. By the time the larva has fully emerged, the hole or opening is large enough to permit the true legs to grasp the edge, and as the hole is enlarged the whole body is drawn in so that it lies in a curved position around the edge. The true legs are gray, quite long, and are fitted for straddling the edge of the leaf and not for walking over the surface. After a few hours of feeding the color of the food begins to show through the body, and the head and true legs become olive brown. There are seven pairs of prolegs, which like the body are pale whitish or greenish-white.

Molting takes place on the edge of the hole eaten out of the leaf wherever the larva happens to be in the course of its feeding. The larva crawls out of the old skin and soon resumes its feeding. The skin usually adheres to the leaf for a time and is not eaten. After the first molt the larva has a length of from 2 to 3 mm. Just after molting the appearance is much as before, except that the head is larger in proportion to the body and both it and the true legs are of a lighter green than the body, which latter is considerably wrinkled and slightly flattened, especially at the caudal end. Later the head

changes to light brown and the wrinkles disappear as the body fills out. After the second molt the average length is about 6 mm. The head appears green and toward the end of the instar is lightly dotted with small brown spots. The folds or wrinkles in the cuticle and sutures appear as white stripes and spots. The length after the third molt is 9.2 mm. While at first the larva is similar in appearance to the preceding instar, the color later is bluish green with whitish lateral and dorsal stripes, due to the folds of the skin. These whitish stripes disappear at maturity, when the folds have become filled out. By the time the larva has cast its first skin (on the average 5½ days after hatching) it has eaten a hole with average diameter of 3.8 mm. After the second molt (on the average 8½ days after hatching) it has eaten out an area of about 12 mm. diameter. Four larvæ were found to have eaten during their larval existence 514, 241, 280, and 416 sq. mm. of leaf, respectively, the first of these having consumed somewhat more than one-fourth of an average-sized pear leaf (Bartlett).

It was found that a considerable percentage of larvæ died at the time of their emergence because they were unable to cut their way through the eggshell or through the leaf. Also during the first instar there was considerable mortality due to unknown causes. During the operation of molting numbers fall to the ground, because the larva retains only a precarious foothold at this time and is easily shaken or knocked off.

The width of a strip of leaf eaten by the larva during one of its circular trips around the hole is equal to three-fourths the height of its head. It eats as far as it can reach forward without advancing. The head of the larva is always closely in contact with the leaf, filling up the place of that portion eaten away, as does also its body, which lies at full length along the edge of the hole (fig. 1, *b*). It is for this reason that the edge of the leaf, defining the hole, appears to be an uninterrupted line, and the larva, being almost the color of the leaf, is not readily detected without close examination, but its presence is made known by the characteristic circular holes that it cuts in the leaves. In feeding the larva holds the posterior end of the body either straight along the edge of the opening or curled about it, and eats around and around the hole, which becomes gradually larger. Where the larvæ are numerous and two or more feed on the same leaf they may soon consume it entirely, whereupon they migrate to other leaves and commence feeding on the edges (fig. 1, *a*), as they are unable to eat through the flat surfaces. The larvæ feeding along the edges of the leaves on the lower part of the tree are mostly those which drop down from above, being dislodged at the time of molting or from some other cause. While migrating along the leaf petioles or the edges of the leaves the posterior part of the body is carried in

a characteristic curled position, and when the larva is disturbed this posterior curled part is thrown up in a threatening manner.

The full grown larva (fig. 1, *c*) measures 12 mm. (0.5 inch) in length and 1.6 mm. in width. The head is light green, dotted antero-dorsally with small brown dots. Upon closer examination these dots are seen to be divided into two or three parts which fit closely together. The eyes are black; the mouth parts dark brown, and the clypeus light brown with a narrow inverted V-shaped band of green between it and the dotted area, which latter extends from the eyes back to the insertion of the head into the thorax and is divided dorso-frontally by a narrow green line. Ordinarily the larva when full grown drops to the ground, but some have been noticed crawling about the trunks of the trees as though crawling to the soil. This is unusual, however, and probably occurs with those larvæ that happen to have been feeding near the main trunk. Just before the larva is ready to drop to the ground for "cocooning," the caudal segments turn yellowish.

THE COCOON AND PUPA.

The cocoon (fig. 2; Pl. I, fig. 4) is cylindrical, slightly constricted at the middle, rounded at the ends and somewhat larger at one end than at the other. It is closely woven of fine silk, smooth inside and roughened or with a pebbled appearance, due to the adherence of small bits of soil, outside. It is at first light greenish and if kept dry remains a straw color, but if moistened, as it usually is when spun in the soil, it soon darkens, becoming a dark brown. Some larvæ spin a quantity of loose, red-brown silk about the outside before spinning the light-green cocoon, especially if the cocoon happens to be spun among old leaves in the soil, and an occasional cocoon is found which is entirely of this red-brown color. The larva lies with its head in the small end of the cocoon, and the posterior part of the body curled up in the larger end. In Washington the average length of 20 cocoons was 5.7 mm. and the average maximum width 3 mm. In California the measurements of both width and length were slightly in excess of this.

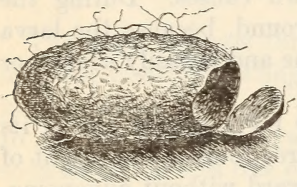


FIG. 2.—Pear leaf-worm: Cocoon. Much enlarged. (Original.)

The habit of cocooning in the soil seems to be for protection rather than for the effect of moisture. Cocoons spun in dry glass vials in May, 1914, gave adults in April, 1915, though they had been kept perfectly dry during the intervening 11 months. The cocoon is closely spun and very tough and undoubtedly prevents the evaporation of any moisture from the inclosed larva. Most of the larvæ spin their cocoons within an inch of the surface, and during the long dry summers of California and Washington this top inch of soil is

subjected to a large amount of heat and desiccation. Thus it is evident that the larva and its cocoon must be able to withstand considerable dryness. An experiment was performed at Wenatchee, Wash., to learn whether moisture was necessary to the larva. Cocoons were collected from the soil within a few days after they were spun, in May, 1914, and divided into two lots, both of which were kept on the surface of some soil in jelly glasses. The soil in one lot was kept moist by pouring water through a glass tube inserted in the soil. The other lot was allowed to remain dry. The first lot was kept moist until September. After this both lots were left untouched until spring, being kept over winter in an unheated room. During the emerging period the first lot was again kept moist, while the other remained dry as before. As a check on these lots the emergence from a third lot, collected April 3, 1915, was recorded. Table I gives the results of this experiment:

TABLE I.—*Adult emergence of pear leaf-worm from moist and dry cocoons, Wenatchee, Wash., April, 1915.*

Observation.	Moist.	Dry.	Cocoons collected Apr. 3, 1915.	Total.
Number of cocoons	59	194	55	308
Number emerged	51	118	31	200
Per cent emerged	86.4	60.8	56.4	64.9

From Table I we learn that 86.4 per cent emerged from cocoons kept moist during the previous summer, 60.8 per cent from dry cocoons, and 56.4 per cent from the cocoons collected April 3, 1915, and which were thus under natural conditions during practically the whole period; the total percentage emerging was 64.9. The cocoons of the dry lot that did not give adults were examined later, and a number of them contained fully-formed adults that had been unable to break through the tough, dry cocoon. This indicates that the smaller percentage of adults emerging from these cocoons was due to the dryness at the time of emergence rather than the dryness during the preceding summer, and perhaps collective dryness weakened the insects somewhat. The larvæ had lived through the dry period of the summer, had pupated the following spring, and the adults had cast the pupal skin, but had been unable to get through the dry cocoon.

The smaller emergence from cocoons collected in April, 1915, is explained by the more uneven conditions to which they had been subjected, such as the freezing and thawing of winter.

The newly-molted pupa is entirely pale green, with black eyes, and measures about 5 mm. by 1.7 mm. Shortly before the time for the adult to emerge the pupa turns dusky blackish, with the wings, forelegs, and portions of middle and hind legs yellowish. Ventrally the abdominal rings and the saw case of the female are greenish.

THE ADULT.

Female.—Length 4.5 mm., very short and robust, shiny; head densely punctured, rather opaque; clypeus very slightly emarginate; frontal wanting or very slightly indicated; antennæ very short, not as long as head and thorax, filiform, third joint longest; intercostal nearly at right angles with costa, interstitial with basal; venation otherwise normal; stigma short, broadly ovate at base; apex of costa strongly thickened; sheath broad, slightly emarginate beneath and acuminate at tip; claws simple. Color black; angles of pronotum, tegulæ, trochanters, apices of femora (particularly anterior pair), tibiæ, and tarsi yellowish ferruginous; the posterior tibiæ and tarsi particularly somewhat infuscated; veins, including stigma and costa, dark brown; wings hyaline.

The females are more robust than the males. Upon issuing from the cocoon the adult cuts a small circular hole almost all the way around the end of the cocoon and issues by pushing up this "lid." Adults (fig. 3) fly preferably in the full sunshine, but also in cloudy weather. Their flight is jerky, and when captured they feign death. A great amount of time is spent running about over the unfolding leaves and buds, the antennæ vibrating incessantly. They take food from the

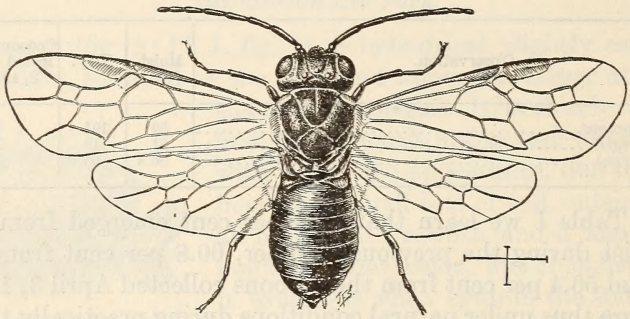
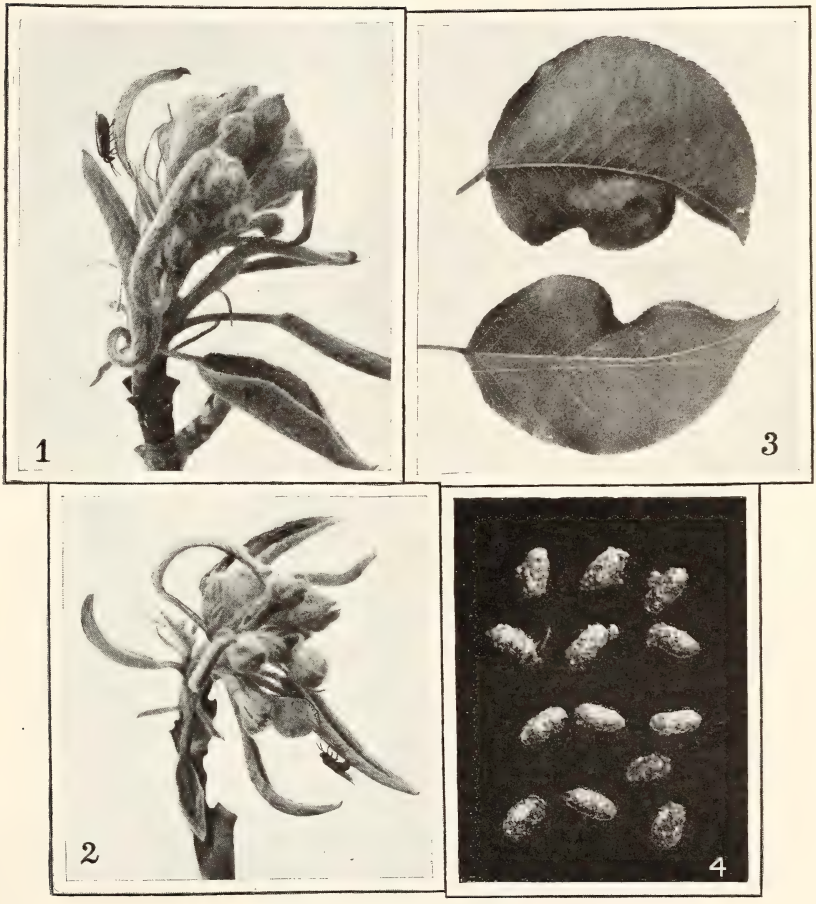


FIG. 3.—Pear sawfly, the adult of the pear leaf-worm. Much enlarged. (Original.)

nectaries of the leaves, and from observations it appears probable that they also make slight incisions with the ovipositor and suck up the moisture which collects at these wounds. (Pl. I, fig. 1.)

When ovipositing they run about in the same way, and at intervals the abdomen is bent down and the tip of the ovipositor inserted in the leaf, always on the under side, the leaves being mostly as yet unrolled. Sometimes the place selected appears to be unsuitable, for the ovipositor is withdrawn after several seconds and inserted in another place (Pl. I, figs. 1, 2). The whole process of oviposition occupies a little less than two minutes. The ovipositor (fig. 4) normally lies in its sheath, point up, and the abdomen must be curved under, so that the point, which is extruded a little way, may be inserted into the leaf. The saws immediately begin to work back and forth, and after about 30 seconds the ovipositor has been driven far enough into the leaf epidermis so that it no longer needs the support of the sheath. At this juncture the abdomen is straightened out, leaving the ovi-



THE PEAR LEAF-WORM.

FIG. 1.—Adult female feeding. FIG. 2.—Adult female ovipositing. FIG. 3.—Leaves deformed by oviposition. FIG. 4.—Cocoons. (Original.)

WORK OF THE PEAR LEAF-WORM.

FIG. 1.—Pear tree; left side sprayed; right side unsprayed, badly defoliated. FIG. 2.—Pear twig showing defoliation by larvæ. (Original.)

positor at right angles to the sheath (fig. 4, *a*). The rhythmical sawing goes on for about 50 seconds more, the two surfaces of the leaf being forced apart to form a more or less oval cavity. The sawing ceases, and the portion of the ovipositor still outside the leaf is seen to become more opaque and greenish. This is due to the passage of the egg and the mucilaginous matter around it. The abdomen moves up and down slightly as the egg is forced into the cavity, and the saws are removed gradually. The actual depositing of the egg occupies about 30 seconds, and as soon as the ovipositor is free the antennæ, which have been practically quiet during the whole operation, immediately resume their rapid vibrations, and the fly moves to a

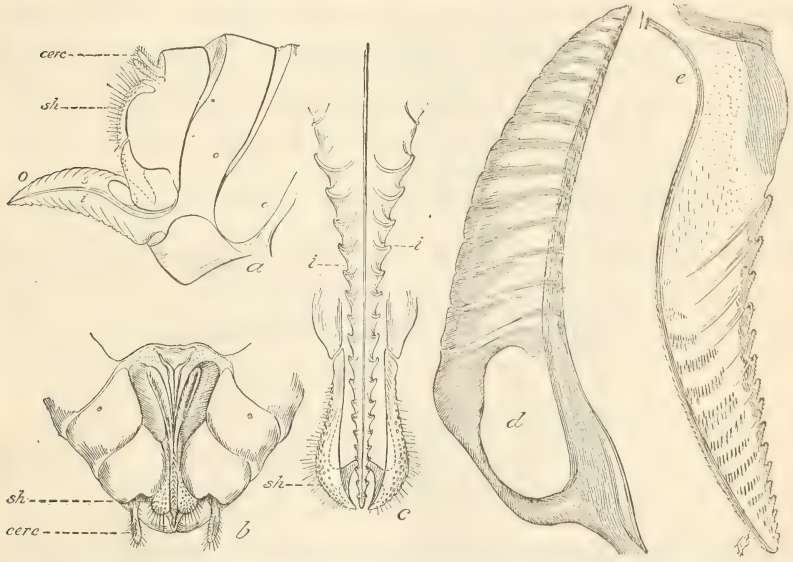


FIG. 4.—Ovipositor of adult female of the pear sawfly: *a*, Last three abdominal segments with ovipositor protruding; *b*, ventral view of last segments of abdomen with ovipositor retracted within its sheath; *c*, ventral view of ovipositor and portion of sheath, showing lateral ridges on inferior blades; *d*, single superior saw blade; *e*, single inferior saw blade; *o*, ovipositor; *s*, superior saw blade; *i*, inferior saw blade; *sh*, sheath; *cerc*, cerci. All highly magnified. (Original.)

new place. One female was observed to deposit 5 eggs in 20 minutes, but not all in the same leaf.

BIOLOGY.

There is one generation annually. In California, from observations made in 1912 and 1913, it was found that adults issued during March and the first half of April, but before the middle of March very few emerged. In Washington, in the spring of 1915, practically all the adults emerged between the 1st and 15th of April. In both localities the period of emergence probably varies more or less with the season.

Immediately after issuing, the sexes presumably mate and the females oviposit on young pear leaves.

THE EGG.

In California, in Santa Clara County, in 1912, eggs were first observed on trees as early as March 23, and in Contra Costa County, in 1913, as early as March 25. During the last few days of March in both these years oviposition was observed. In Washington, in 1915, numerous females were observed in the Zimmerman orchard on April 7, though none had been found 3 days before. None was seen to oviposit on this date, and they were evidently all very recently emerged. A week later the period of oviposition was at its height and by April 24 most of the adults had disappeared. The adults prefer to oviposit on those varieties of pears which leaf out early and generally select for oviposition a young leaf not yet unrolled. In California the earliest adults generally find the Bartlett not far enough advanced, and so the earliest eggs are deposited on other varieties. Ovipositing females kept in a jar were provided with cherry and plum leaves, but they refused these as hosts, although, in similar confinement, they oviposited regularly in pear leaves.

Table II indicates the incubation period in California for 85 eggs:

TABLE II.—*Incubation record of eggs of the pear leaf-worm, Walnut Creek, Cal., 1913.*

Number of eggs deposited.	Date of deposition.	Date of hatching.	Number hatched.	Incubation stage.
				Days.
118	Mar. 29	Apr. 7	23	9
		Apr. 8	6	10
		Apr. 9	21	11
		Apr. 10	28	12
		Apr. 11	5	13
		Apr. 12	2	14

For this experiment 20 adults were confined in a cage in which a growing pear limb was inclosed. The average incubation stage was 11.1 days. Out of 118 eggs deposited, 85, or 72 per cent, hatched.

Table III indicates the incubation period, in Washington, of 23 eggs deposited by a single unfertilized female on a pear twig kept in water.

TABLE III.—*Incubation record of eggs of the pear leaf-worm, Wenatchee, Wash., 1915.*

Number of eggs deposited.	Date of deposition.	Date of hatching.	Number hatched.
47	Apr. 11–14	Apr. 19	10
		Apr. 20	4
		Apr. 21	1
		Apr. 22	1
		Apr. 23	6
		Apr. 24	1

Another lot, deposited from April 8 to 11, began hatching April 18. The incubation period was thus 8 to perhaps 12 or 13 days. The twig above cited was badly wilted by the 24th, after only 50 per cent of the eggs had hatched, and none hatched after this date. It is probable that under normal conditions hatching would have been more regular, and also that the average incubation period would have been lengthened. It was observed that unfertilized eggs hatched as readily as fertilized ones. The life-history phase of parthenogenesis is considered farther on in this chapter in the discussion of the adult.

THE LARVA.

In the field at Walnut Creek, in 1913, the first larva was observed on April 1. It was about 3 days old. Two days later about 1 per cent of the eggs already laid had hatched. At Red Bluff, Tehama County, Cal., in 1911, most of the larvæ were half grown on April 9, and in 1912 full-grown larvæ were found at Red Bluff April 22, and on May 12 no more larvæ could be found.[1] At Suisun and Courtland, Cal., in 1912, the first larvæ went to the ground about April 10, but at San Jose not before May 1. In 1913, at Walnut Creek, the first larvæ went to the ground about April 20, and after May 10 very few larvæ remained on the trees. It appears that in the interior valleys, where the pear trees move earlier, the sawflies emerge and the larvæ mature earlier than in the coastal districts. This is doubtless due to climatological influences.

The first molt is cast from 3 to 8 days after hatching, the second molt from 2 to 7 days after the first, the third molt from 2 to 7 days after the second, and from 4 to 10 days elapse between the date of the third molt and maturity of the larva, the variations being chiefly due to temperature influences. The pupal molt does not take place until the following spring or shortly before the issuance of the adult. Table IV indicates the larval life observed at San Jose, Cal., in 1912.

TABLE IV.—*Larval stages of the pear leaf-worm, San Jose, Cal., 1912.*

No.	Date egg hatched.	Date larva spun cocoon.	Active larval life.	No.	Date egg hatched.	Date larva spun cocoon.	Active larval life.
			Days.				*Days.*
1	Apr. 7	May 9	32	10	Apr. 12	May 15	33
2	...do.....	May 10	33	11	Apr. 13	May 12	29
3	...do.....	May 12	35	12	...do.....	May 14	31
4	Apr. 8	May 11	33	13	...do.....	...do.....	31
5	...do.....	...do.....	33	14	...do.....	May 16	33
6	Apr. 9	May 9	30	15	...do.....	May 18	35
7	Apr. 10	May 17	37	16	Apr. 17	May 13	26
8	Apr. 12	May 10	28	17	May 2	May 31	29
9	...do.....	May 11	29				

[1] Letter from Mr. C. B. Weeks, Tehama County horticultural commissioner.

Thus the maximum larval life was 37 and the minimum 26 days. The average is found to be 31.6 days. In this experiment the larvæ were kept in glass vials, but in the experiment of which the results are given in Table V the larvæ were allowed to remain on the tree until a day or two before they went to the soil, a small numbered cloth tag attached to each leaf permitting accurate observation on each larva. The observations recorded in Table V are, therefore, more normal than those indicated in Table IV.

TABLE V.—*Larval stages of the pear leaf-worm, Walnut Creek, Cal., 1913.*

No.	Date of—					Length of instars in days.				Total.
	Hatching.	Molt 1.	Molt 2.	Molt 3.	Spinning cocoon.	1	2	3	4	
1	Apr. 13	Apr. 19	Apr. 24	Apr. 28	May 2	6	5	4	4	19
2	...do.....	Apr. 20	...do.....	...do.....	May 3	7	4	4	5	20
3	...do.....	...do.....	...do.....	...do.....	...do.....	7	4	4	5	20
4	...do.....	Apr. 21	...do.....	...do.....	May 4	8	3	4	6	21
5	...do.....	...do.....	...do.....	...do.....	May 5	8	3	4	7	22
6	...do.....	Apr. 19	...do.....	(?)	May 1	6	5	(?)	7	18
7	...do.....	Apr. 20	(?)	Apr. 26	May 3	7	(?)	(?)	7	20
8	Apr. 14	Apr. 19	Apr. 23	(?)	...do.....	5	4	(?)	(?)	19
9	...do.....	Apr. 20	...do.....	Apr. 26	May 4	6	3	3	8	20
10	...do.....	...do.....	...do.....	Apr. 29	May 3	6	3	6	4	19
11	...do.....	Apr. 21	Apr. 24	Apr. 27	May 4	7	3	3	7	20
12	...do.....	...do.....	...do.....	Apr. 28	May 3	7	3	4	5	19
13	...do.....	...do.....	...do.....	...do.....	May 4	7	3	4	6	20
14	Apr. 15	Apr. 20	...do.....	(?)	...do.....	5	4	(?)	(?)	19
15	...do.....	Apr. 21	...do.....	Apr. 30	May 7	6	3	6	7	22
16	Apr. 16	Apr. 20	Apr. 23	Apr. 25	Died.	4	3	2		
17	...do.....	...do.....	Apr. 24	Apr. 26	May 3	4	4	2	7	17
18	...do.....	Apr. 22	...do.....	Apr. 28	May 4	6	2	4	6	18
19	...do.....	...do.....	Apr. 25	Apr. 27	May 5	6	3	2	8	19
20	...do.....	...do.....	...do.....	Apr. 30	May 9	6	3	5	9	23
21	Apr. 17	...do.....	...do.....	...do.....	Died.	5	3	5		
22	...do.....	Apr. 23	...do.....	Apr. 28	May 6	6	2	3	8	19
23	...do.....	...do.....	...do.....	Apr. 30	May 6	6	2	5	6	19
24	...do.....	...do.....	Apr. 26	May 2	May 8	6	3	6	6	21
25	Apr. 18	...do.....	Apr. 25	Apr. 30	May 5	5	2	5	5	17
26	...do.....	...do.....	...do.....	...do.....	May 6	5	2	5	6	18
27	...do.....	...do.....	...do.....	...do.....	May 8	5	2	5	8	20
28	...do.....	...do.....	Apr. 26	Apr. 29	May 9	5	3	3	10	21
29	...do.....	Apr. 24	...do.....	...do.....	May 8	6	2	3	9	20
30	Apr. 19	...do.....	...do.....	Apr. 28	Died.	5	2	2		
31	...do.....	...do.....	...do.....	May 2	May 7	5	2	6	5	18
32	...do.....	...do.....	Apr. 28	...do.....	May 12	5	4	4	10	23
33	Apr. 20	...do.....	Apr. 26	Apr. 28	May 8	4	2	2	10	18
34	...do.....	...do.....	Apr. 28	May 5	Died.	4	4	7		
35	Apr. 21	...do.....	Apr. 27	May 2	May 8	3	3	5	6	17
36	...do.....	...do.....	...do.....	May 3	May 10	3	3	6	7	19
37	...do.....	...do.....	Apr. 28	May 1	May 9	3	4	3	8	18
38	...do.....	...do.....	...do.....	May 4	...do.....	3	4	6	5	18
39	...do.....	Apr. 25	Apr. 29	...do.....	...do.....	4	4	5	5	18
40	...do.....	...do.....	May 1	May 6	May 13	4	6	5	7	22
41	Apr. 22	...do.....	Apr. 29	May 2	May 8	3	4	3	6	16
42	...do.....	Apr. 26	May 2	May 6	May 14	4	6	4	8	22
43	Apr. 23	...do.....	...do.....	...do.....	May 12	3	6	4	6	19
44	...do.....	...do.....	May 3	...do.....	...do.....	3	7	3	6	19
45	...do.....	Apr. 30	May 4	May 9	May 14	7	4	5	5	21
46	Apr. 25	May 1	May 6	May 10	May 16	6	5	4	6	21
47	May 7	May 14	May 17	May 22	May 27	7	3	5	5	20

Out of the 47 individuals recorded in Table V, it will be noticed that 4 died after completing their third molt. These 4 were full grown and died from their inability to spin cocoons, and it appears that the larva, after it is ready to enter its quiescent stage, can not live exposed to the atmosphere. For the experiment in

Table V, 122 eggs were marked on the trees. Thirty eggs died before hatching or were infertile. The remaining 92 hatched and 16 larvæ disappeared and 3 died before molting. Thus 73 larvæ cast their first skin under observation. Of these, 6 disappeared and 2 died before casting the second skin. Thus 65 larvæ molted a second skin under observation. Of these, 5 disappeared and 5 died (1 being destroyed by a coccinellid larva) before shedding the third skin. Of the 55 larvæ which cast the third skin, 8 subsequently disappeared before they were ready to drop to the ground. The larvæ under observation were taken into the laboratory insectary after their third molt, but were not inclosed in cages, so that those which desired to move away could do so. On the trees most of the larvæ which disappeared were dislodged during the operation of molting.

TABLE VI.—*Summary of Table V.*

Instar.	Maximum.	Minimum.	Average.
	Days.	*Days.*	*Days.*
1	8	3	5.3
2	7	2	3.4
3	7	2	4.2
4	10	4	6.6
Total larval period on trees	23	16	18.4

The data in Tables V and VI are in striking contrast to those recorded from San Jose (Table IV), in which the average period spent by the larvæ in vials was 31.6 days. It would appear that the San Jose individuals were retarded by reason of the abnormal character of their food as a result of the feeding of cut leaves. It might be added that the temperature during the period of larval growth in 1913 at Walnut Creek was higher than the mean average for that time of year, and toward the end of April great daily fluctuations occurred; for instance, on April 24 and on May 3 there was a range of 48° F.

Tables VII and VIII give the larval life history at Wenatchee, Wash., in 1915.

TABLE VII.—*Larval life history of the pear leaf-worm at Wenatchee, Wash., 1915.*

No.	Date of—					Length in days.			
	Hatching.	1st molt.	2d molt.	3d molt.	Cocoon.	1	2	3	4
1	Apr. 16	Apr. 23				7			
2	Apr. 18	Apr. 25	May 2			7	7		
3	...do....	...do....	Apr. 29	May 7	May 14	7	4	8	7
4	Apr. 19	...do....	Apr. 28	May 6		6	3	8	
5	...do....	Apr. 26	Apr. 30			7	4		
6	...do....	...do....	May 1			7	5		
7	...do....	...do....	...do....			7	5		
8	...do....	...do....	May 4			7	8		
9	...do....	...do....				7			
10	...do....	...do....				7			
11	...do....	...do....				7			
12	Apr. 21	...do....	May 2			5	6		
13	...do....	...do....	May 3			5	7		
14	...do....	...do....				5			
15	...do....	Apr. 27	May 5			6	8		
16	...do....	...do....				6			
17	Apr. 22	Apr. 28	May 5			6	7		
18	Apr. 23	...do....	...do....			5	7		
19	...do....	...do....	...do....			5	7		
20	...do....	...do....				5			
21	...do....	Apr. 29				6			
22	...do....	...do....				6			
23	...do....	Apr. 30				7			
24	Apr. 24	Apr. 29				5			
25	...do....	...do....				5			
26			Apr. 29	May 7				8	
27			May 8	May 17				9	
28			May 9	May 15				6	
29			...do....	...do....				6	
30			May 15	May 23				8	
31			...do....	...do....				8	
32			...do....	...do....				8	
33			May 17	May 24				7	
34				Apr. 23	Apr. 29				6
35				May 8	May 18				10
36				May 12	May 21				9
37				...do....	May 22				10

TABLE VIII.—*Summary of Table VII.*

Instar.	Maximum.	Minimum.	Average.
	Days.	*Days.*	*Days.*
1	7	5	6.1
2	8	3	6.0
3	9	6	7.6
4	10	6	8.4
Total			28.1

In ascertaining the larval life history at Wenatchee, it was necessary, owing to the distance of the infested orchard, to rear the larvæ on leaves kept in water in the outdoor rearing shelter. These had to be renewed every 4 or 5 days, and the larvæ transferred to the fresh leaves. It will be noted that there was a high mortality among the larvæ, and this may be attributed to the fact that the larvæ had to be handled more or less, and that they did not always have perfectly fresh food upon which to feed. It is probable, also, that the periods between molts were lengthened by this abnormal method of rearing, although observations in the field indicate that the figures for the total larval life are approximately correct. In 1915 most of

the larvæ had hatched by April 24, and the largest number were entering the soil about May 20, giving an average larval period of about 26 days. The table shows an average of 28.1 days, and the only larva that was reared to maturity (No. 3) occupied 26 days from egg to cocoon. This is a longer period than at Walnut Creek, Cal. (18.4 days) where the larvæ were reared normally on the trees, and a slightly shorter period than at San Jose (31.6 days), where the larvæ were reared under conditions similar to those in Washington State.

THE COCOON AND PUPA.

In order to determine how deeply the larvæ penetrate the earth for the purpose of spinning their cocoons, 60 full-grown larvæ were placed in a screen cage sunk into the soil and filled with 7 inches of average orchard soil April 30, 1913. By May 3 all the larvæ had burrowed and on June 18 the soil was examined with the results enumerated in Table IX.

TABLE IX.—*Depth in soil for cocooning of the pear leaf-worm, Walnut Creek, Cal., 1913.*

Number of cocoons found.	Inches below soil surface.
46	0 to 1
2	1 to 2
4	2 to 3
1	3 to 4

Fifty-three out of 60 were thus accounted for, and therefore 88.3 per cent of the larvæ spun cocoons. It is evident from Table IX that the great majority spin their cocoons not more than 1 inch below the surface. In the above instance this majority was 86.8 per cent.

Table X shows the depth in the soil at which the cocoons are spun in Washington. On May 21, 1915, 93 larvæ just ready to enter the earth were placed in an open jar on top of 6 inches of fairly closely packed, moist, sandy soil, which is typical of the orchards of the region. In a few days the larvæ had all disappeared and on June 11 the soil was sifted and 71 cocoons were recovered. Thus 76.3 per cent of the larvæ spun cocoons, the others being found dead near the surface. The depths at which the cocoons were found are given in Table X.

TABLE X.—*Depth in soil of cocoons of pear leaf-worm, Wenatchee, Wash., 1915.*

Number of cocoons found.	Inches below surface.
39	0 to ½
24	½ to 1
7	1 to 2
1	2 to 3

Thus 88.7 per cent of all the cocoons were formed less than 1 inch below the surface of the soil. This approximates the percentages found at this depth in California.

Tables XI, XII, and XIII indicate the period spent in the cocoon in California:

TABLE XI.—*Cocoon records of the pear leaf-worm, 1911–12.*

Place.	Date of spinning cocoon.	Date of adult emergence.
San Jose, Cal.	May 13, 1911	Mar. 25, 1912
Do.	May 16, 1911	Mar. 18, 1912
Do.	....do....	Do.
Red Bluff, Cal.	Apr. 25, 1911	Mar. 4, 1912
Do.	Apr. 26, 1911	Mar. 10, 1912
Do.	....do....	Do.

TABLE XII.—*Cocoon records of the pear leaf-worm, 1912–13.*

Place.	Date of spinning cocoon.	Date of adult emergence.
San Jose, Cal.	May 9, 1912	Mar. 23, 1913
	May 10, 1912	Mar. 30, 1913
	May 11, 1912	Mar. 28, 1913
	....do....	Mar. 8, 1913
	May 12, 1912	Mar. 31, 1913
	May 15, 1912	Mar. 7, 1913

TABLE XIII.—*Cocoon records of the pear leaf-worm, Walnut Creek, Cal., 1913–14.*

Date of spinning cocoon, 1913.	Date of adult emergence, 1914.	Date of spinning cocoon, 1913.	Date of adult emergence, 1914.	Date of spinning cocoon, 1913.	Date of adult emergence, 1914.	Date of spinning cocoon, 1913.	Date of adult emergence, 1914.
May 2	Mar. 18	May 4	Mar. 18	May 7	Mar. 20	May 9	Mar. 20
May 3	Mar. 14	...do....	...do....	May 8	Mar. 19	...do....	Do.
Do.	Mar. 15	...do....	Mar. 19	...do....	Mar. 20	May 12	Do.
Do.	Mar. 18	May 5	Mar. 15	...do....	Mar. 21	...do....	Mar. 25
Do.	Mar. 19	...do....	Mar. 20	...do....	Mar. 29	May 13	Mar. 18
Do.	...do....	May 6	Mar. 18	May 9	Mar. 16	...do....	Mar. 19
Do.	Mar. 20	...do....	Mar. 20	...do....	Mar. 18	May 14	Mar. 31
May 4	Mar. 15	May 7	Mar. 18	...do....	Mar. 19	May 16	Mar. 22
Do.	Mar. 18						

The average time spent underground in a cocoon, first as larva and secondly as pupa, is about 10 months and 10 days. Table XIV summarizes the adult emergence recorded in Table XIII.

TABLE XIV.—*Summary of Table XIII, adult emergence of the pear leaf-worm, 1914.*

Number of adults issuing.	Date.	Number of adults issuing.	Date.
1	Mar. 14	1	Mar. 21
3	Mar. 15	1	Mar. 22
1	Mar. 16	1	Mar. 25
8	Mar. 18	1	Mar. 29
8	Mar. 19	1	Mar. 31
8	Mar. 20		

Another lot of 53 cocoons gave almost similar results, the days on which the greatest numbers issued being March 16 and 17.

In 1913 a number of cocoons were examined March 10, and none of the inmates were pupæ. On March 13 one newly molted pupa was observed. It was entirely pale green, with black eyes, and measured 5 mm. by 1.7 mm. On March 30 this pupa began to turn dusky, and on April 2 the head and thorax were black and the abdomen dusky. This pupa failed to develop, but would have issued as an adult about April 5. On March 28, 1913, a fully formed adult was found inside a cocoon. The pupal stage is passed in from two to three weeks.

THE ADULT.

Table XV indicates the adult emergence in Washington of 200 individuals, and their sex, in the spring of 1915.

TABLE XV.—*Adult emergence of the pear leaf-worm, Wenatchee, Wash., 1915.*

Date.	Males.	Females.	Total for each date.	Date.	Males.	Females.	Total for each date.
Apr. 2	0	4	4	Apr. 9	0	8	8
Apr. 3	0	1	1	Apr. 10	0	17	17
Apr. 4	1	12	13	Apr. 11	0	7	7
Apr. 5	1	25	26	Apr. 12	0	3	3
Apr. 6	0	53	53	Apr. 13	0	1	1
Apr. 7	0	52	52				
Apr. 8	0	15	15	Total.	2	198	200

The average length of life of 7 females confined in jars with pear twigs was 5½ days. Comparing the adult emergence in California in 1914 with that in Washington in 1915, we find that in the former locality the maximum date was March 19, while in the northern locality this date was April 6. The activities of the insect certainly commence earlier in the year in California, and this is to be expected when we consider the seasonal differences in the two localities, for the activities correspond with the period of leafing of the tree.

Both in Washington and in California the females have been observed to outnumber the males greatly. Out of 200 adults reared at Wenatchee, Wash., in 1915, only two were males.

Parthenogenesis occurs in this species, and unfertilized eggs hatch readily, as already has been stated. The larvæ live for some time, some of them until the third instar, but it is not definitely known whether any of them ever live to maturity.

NATURAL CONTROL.

Although the pear leaf-worm is apparently a native species, its natural enemies seem to be few, and inefficient in controlling it. No parasites whatever have been recorded in California. At Wenatchee, Wash., several old cocoons, each with a small round hole near one end,

were found in May, 1914, indicating the probable existence of a parasite. In the spring of 1915 the possibility of securing parasites was kept in mind. On April 1 three small parasites were found in one of the rearing jars, evidently coming from a single cocoon that had a small hole in it. The following day the sawflies began emerging, and continued to do so until April 13. At this time there were still over a hundred cocoons in the jars, and these were kept for possible parasites.

On April 24 a small ichneumonid, determined by Mr. S. A. Rohwer, of the Bureau of Entomology, as *Mesoleius* sp., emerged from one of the cocoons through quite a large hole that it had made.

On May 4, 27 specimens of the small parasite previously referred to were found in one of the rearing jars, having come from four different cocoons, and in another jar 15 specimens of the same species had emerged from three cocoons, or an average of 6 parasites for each cocoon. These parasites, evidently chalcidids, have not been determined.

On May 19 a single larger parasite was found, which, upon being submitted to Mr. S. A. Rohwer, proved to be a chrysidid, probably *Cleptes provancheri* Aaron.

Thus it appears that of 308 cocoons, only 10, or a little over 3 per cent, were parasitized. The ravages of the sawfly would not be diminished to any appreciable extent by this degree of parasitism, though there may be years when these parasites are much more numerous. It is interesting to note that practically all of these parasites came out considerably later than the adult sawflies, and at about the time when the largest number of sawfly larvæ were full grown. This indicates that the parasites oviposit on the larvæ, which is probably the case, as it is difficult to understand how they could reach the larvæ after the latter had spun their cocoons in the soil. Since there is but one brood of the host, there would be only a single brood of the parasites if peculiar to this host.

In California larvæ of coccinellid beetles in rare instances have been observed to prey on the larvæ of the pear sawfly. Before the first of May coccinellid larvæ are comparatively scarce, and so it is unlikely that they will ever prove a check upon the pear sawfly.

REMEDIAL MEASURES.

The pear leaf-worm is easily controlled when in the larval stage. A poison spray, such as arsenate of lead, if properly applied, is highly effective (Pl. II, fig. 1), because of the habit possessed by this insect of passing the whole period of this stage of its life upon the same leaf, unless forced to move away by interference, accident, or scarcity of food, mainly due to the location of several larvæ on one leaf and the fact that they consume it before they attain the stage of pupation.

The larva shows no preference for any one part of the leaf. The parenchyma and main or lateral veins—even blister-mite galls, when these happen to be present—are consumed in turn as met with during the continuous circular travel of the larva. A spot of arsenate of lead reached in its path of travel becomes part of its food. The larva does not change its course or eat around it because of a dislike for the taste of the poison.

The larval period occurs at a time when spraying is done for more serious pests of the pear. Spraying specifically for its control would coincide with the first application of spray for the codling moth, when the blossoming period is about over and two-thirds of the petals have fallen. The formula of arsenate-of-lead spray used for the latter is quite as effective for the pear leaf-worm.

CALIFORNIA EXPERIMENTS.

In California, when pear orchards are infested with pear thrips (*Taeniothrips pyri* Daniel), the Government formula of distillate-oil emulsion and nicotine[1] used for the control of the pear thrips larva is usually applied at a time when the pear leaf-worms are about all hatched, and is also effective, as a contact-spray control, for the latter.

Therefore, in pear orchards well taken care of, when spraying for the codling moth has become as much of an indispensable practice as that of plowing and cultivating, the pear leaf-worm has less chance of becoming a pest of economic importance, and its control can be considered as correlative with that of both the codling moth and the pear thrips.

TABLE XVI.—*California spraying experiments indicating degree of efficiency of different formulas against the pear leaf-worm, Apr. 29 and 30, 1913.*

Tree sprayed and spray material used.	Number of pear leaf-worms.				
	Dead.	Alive.	Sick.	Per cent dead.	Per cent alive.
Tree No. 1: Lead arsenate 4 pounds, water 100 gallons	31	1	2	91	3
Tree No. 2: Lead arsenate 4 pounds, fish-oil soap 10 pounds, 40 per cent nicotine sulphate 1/1600, water 100 gallons	50	0	0	100	0
Tree No. 3: Fish-oil soap 10 pounds, 40 per cent nicotine sulphate 1/1600, water 100 gallons	17	15	2	50	44
Tree No. 4: Lead arsenate 4 pounds, fish-oil soap 10 pounds, 40 per cent nicotine sulphate 1/1600, water 100 gallons	46	5	1	88½	9½
Tree No. 5: Lead arsenate 4 pounds, fish-oil soap 10 pounds, water 100 gallons	38	17	2	66½	30
Tree No. 6: Lead arsenate 6 pounds, water 100 gallons	39	1	0	97½	2½
Tree No. 7: Fish-oil soap 10 pounds, 40 per cent nicotine sulphate 1/1600, water 100 gallons	16	14	0	53.3	46.6

[1] Foster, S. W., and Jones, P. R. How to Control the Pear Thrips. U. S. Dept. Agr. Bur. Ent. Circ. 131. 24 p., 15 fig. 1911.

To ascertain how far the control of the pear pests just mentioned could be relied upon to keep the pear leaf-worm in check, control experiments were made in the spring of 1913 in California and in 1915 in the State of Washington, and are shown in Table XVI.

Actual count was made 24 hours after spraying, and the larvæ found on the leaves only were taken into consideration. Leaves with holes eaten in them, but with no larvæ present, were not made part of the record. This spray was applied with pressure, the force of which, when hitting the leaves at close range, more than likely caused larvæ to loosen their hold and fall to the ground. It is also more than probable that some sick larvæ likewise fell before the count was made. At that time leaves were noticed with holes in them smaller than those which would have been produced by larvæ remaining on the leaf until their full development had been attained. The mortality therefore would be greater than is recorded in these tables, and this accounts in a measure for the difference in the results found for the same formula applied in California and in the State of Washington, because in the latter instance the experiment was made under laboratory conditions which would afford opportunity for closer observations and would yield more precise results.

Field conditions prevailed in the California experiments, because common every-day spraying, as ordinarily practiced in orchards for other pests, was the only object in view as a control at the same time for the pear leaf-worm.

In the control table (Table XVI) the experiments with tree No. 3 and tree No. 7, in which a contact spray was used containing fish-oil soap and extract of nicotine, indicate a comparatively small percentage of mortality compared to that in which the material contained in addition arsenate of lead, as in the experiment with tree No. 2. But it must be mentioned that in the case both of tree No. 3 and of tree No. 7, the absence of larvæ on leaves with holes when the count was taken was very conspicuous and the larvæ that survived were all large.

A contact spray, whether with or without the addition of distillate oil, is a mechanical emulsion or mixture, which, to be effective, requires application with greater pressure than does a poison spray. Because of this, the liquid strikes the leaves with enough force to dislodge many of the worms, which drop to the ground, where death ensues, caused by the spray adhering to them.

The addition of fish-oil soap to a mixture of water and nicotine extract increases the efficiency of the spray by imparting to the liquid more penetration and better spreading and adhering properties.

WASHINGTON EXPERIMENTS.

In Washington State, where the pear thrips is not to be considered, lead arsenate would appear to be the only logical insecticide to be used against the pear leaf-worm. It is less expensive than extract of tobacco sprays, and easier to mix than oil sprays; besides, the lead arsenate can serve a double purpose—that of controlling this worm and, at the same time, the codling moth. The first application of lead arsenate for the control of the latter is made when the petals of the pear blossom drop, and at this time the larvæ of the sawfly have reached the second instar. The injury done previous to this is negligible; it is only during the last two instars that the larvæ cause serious injury to the foliage.

Mr. Zimmerman, in whose orchard the worst infestation occurred, used lead arsenate at the rate of 4 pounds to 100 gallons of water against the pear leaf-worm with excellent results, both in 1914 and in 1915. The first year there was a very severe infestation of larvæ and the application was made May 16, at the same time that the first codling-moth spray was applied to apples; this was too late for the pears, as the larvæ already had devoured as much as a third of many of the leaves. However, it saved most of the trees from a severe defoliation, as is shown in Plate II, which pictures a tree of which the left half was sprayed while the right half was left unsprayed, the photograph having been taken on May 21, 5 days after the trees were sprayed. The difference was very marked. No definite count was made, but on the sprayed trees scarcely any living larvæ could be found, while many limp and blackened remains were hanging from the partially eaten leaves. In the unsprayed portion of the tree just mentioned, which served as a check, larvæ were numerous, and large numbers of them were dropping to the ground to spin their cocoons.

In 1915 the infestation was not so severe, owing to the control measures of the year before. The orchard was sprayed on May 6, earlier than in 1914. Lead arsenate was used at the same strength as before, that is, 4 pounds to 100 gallons of water. This application effectually checked the ravages of the larvæ, and the trees suffered very little injury.

In 1915 a small experiment was performed with nicotine sulphate, 40 per cent concentration. Infested twigs were placed in water and sprayed with a hand pump. April 27 a twig with 10 second-instar larvæ was sprayed with the nicotine sulphate at the rate of 1 to 1,200, with the addition of a little fish-oil soap. On April 28 the twig was examined and all the larvæ found dead. The larvæ on a check twig were still alive. On this date a similar twig was sprayed in the same way, except that the nicotine sulphate was

diluted to 1 to 2,000. This time the check twig was sprayed with clear water. An examination on April 29 showed that all the larvæ sprayed with nicotine were dead, while those sprayed with water were alive.

Control by cultivation is not successful. The Washington orchard in which the spraying was done was kept well cultivated all summer, the soil being in a finely pulverized condition and a dust mulch being maintained for the conservation of moisture. The orchard had been kept in this condition for several years. The cultivation evidently, as a measure of control, had but little effect on the cocoons in the soil. Many of the cocoons are located too near the trunk of the tree to be susceptible of mechanical injury by the teeth of the cultivator, but aside from this they are tough and resist rough treatment, and moisture seems to be an indifferent agent, as indicated in Table I (p. 7), pertaining to moisture conditions.

SUMMARY.

The pear leaf-worm (*Gymnonychus californicus* Marlatt), so far as is known, is a native of the Pacific coast.

Its original host is probably some one or more wild species of plants related to the pear, such as the service berry (Amelanchier), thorn apple (Crataegus), or mountain ash (Sorbus). As to cultivated plants, its selection of food is restricted to the different varieties of pears.

There is only one generation each year. The adult or parent sawflies issue in March and April, the female sex greatly predominating. Eggs are inserted into the pear leaves, the resultant larvæ or worms feeding upon the foliage for an average period of 3 weeks. The larvæ may be found on the leaves during April and May, and in Washington the season is perhaps 10 days or 2 weeks later than in California. Upon acquiring full growth the larvæ drop to the ground and bury themselves in the topmost inch of soil (a few go as deep as 3 or 4 inches) and weave around themselves a brown, oval, tough cocoon in which the insect remains for slightly over 10 months, at first as larva and later for a period of 2 or 3 weeks as a pupa. At the end of the pupal stage the adult issues from the cocoon and comes forth from the ground, and thus the cycle is completed.

Injury is confined to the foliage of the hosts and is done almost entirely by the larva or worm, the presence of which is readily detected by the characteristic circular holes it eats in the leaves. Generally it is of slight economic importance, but in cases of severe attacks trees have been defoliated and have suffered badly.

What few natural enemies the insect has are quite unable to control it. Artificial remedies are correlative with those used against the codling moth and also against the pear-thrips larva, and these are respectively as follows:

Poison spray.—Four pounds lead arsenate to 100 gallons water.

Contact spray.—Fish-oil soap 4 pounds; water 100 gallons; nicotine sulphate (40 per cent concentrate) 1 to 1,200; also the Government formula of distillate-oil emulsion and sulphate of nicotine.[1]

In cases of ordinary infestation the contact spray such as is used for thrips larvæ or aphids will prove successful in controlling the larva of the pear leaf-worm. When the infestation is severe and promises the defoliation of limbs or whole trees the poison spray should be used. The best time for application is when the largest larvæ are about half grown and when the holes in the leaves are not larger than one-half inch in diameter. At this time nearly all the eggs have hatched.

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